III.

THE FAUNA ASSOCIATED WITH THE CRINOIDS OF A TROPICAL CORAL REEF: WITH ESPECIAL REFERENCE TO ITS COLOUR VARIATIONS.

By F. A. POTTS, M. A.,

Fellow of Trinity Hall and Balfour Student of the University of Cambridge, England.

One plate and seven text-figures.

CONTENTS.

THE FAUNA ASSOCIATED WITH THE CRINOIDS OF A TROPICAL CORAL REEF: WITH ESPECIAL REFERENCE TO ITS COLOUR VARIATIONS.

By F. A. Potts, M. A.

INTRODUCTION.

Although so much attention has been devoted to the phenomena of mimicry and protective resemblance displayed by land animals, in only one case has the colour resemblances of a marine animal been exhaustively studied. I refer to the classical instance of *Hippolyte varians*, illustrated by a long series of ingenious observations made by Gamble and Keeble. Briefly stated, the story is as follows: The young *Hippolyte* is free-swimming and colourless, but it becomes virtually a sedentary animal, anchoring itself to a seaweed or hydroid in the Laminarian zone, on which it finds both food and shelter. The prawn has the power of forming red, yellow, and blue pigments and by altering their relative proportions in the chromatophores it can acquire a green, brown, blue, or red ground-colour, and is thus able to adapt itself to the varied colours of the seaweeds and hydroids. The pigment may be laid down in longitudinal stripes or horizontal bars and in this way a colour scheme can be formed matching whatever seaweed the prawn shelters in. In early life a change in habitat is followed by a readjustment of the pigment altering the colour scheme, but this power is soon lost.

There are, however, a great number of cases where species of small marine animals are associated with an environment not varying, as in the case of *Hippolyte*, but definitely fixed for the species—for instance, some particular kind of sedentary animal, sponge, alcyonarian, or crinoid, as the case may be, which it frequents for shelter and commonly resembles in colour. Sometimes the first is definitely a parasite on the second, as in an example of the phenomenon often noted at Murray Island, where the bright blue starfish *Linckia lævigata*, so widely spread on the Indo-Pacific reefs, was a source of food to multitudes of tiny copepods (*Linckiomolgus cæruleus* Stebbing), whose colour exactly matches that of the host, though the pigment is of a different chemical nature.

In the majority of cases the association is of a vaguer nature, and while the associated animal gains protection it obtains its own food-supply. How numerous such cases are in tropical seas may be seen from the following passage:

"We noticed numerous other animal partnerships, which might have been cases of commensalism but were more probably merely one-sided adaptations of one animal standing in need of protection to another animal capable of affording the required protection without any expenditure of effort. For instance, a very common branching zoophyte of this region is *Spongodes pustulosa* (or some very closely related species), a creature near akin to the 'dead men's fingers' of British seas. It looks like a small 'run to seed' cauliflower, of which the individual florets are of a bright pink colour. Hidden among its branches we found no less than four small species of crustaceans (an *Alpheus*, a *Galathea*, a *Porcellana*, and a rare little spider crab known as *Hoplophrys oatesi*), all of which, in life, are greyish white, with bright pink spots, so that they are perfectly invisible so long as they remain quiet in their living refuge. Another zoophyte that we often dredged was *Pteræides elegans* (or a species intimately close to it), one of the seapens, of a grey colour profusely marked with little blackish rings. In its leaves three small species of crustaceans are accustomed to hide, all of which are coloured and spotted exactly like the living citadel in which they dwell. I have already mentioned the sea-lily (*Actinometra*), striped in alternate bands of yellow and purple, on whose fronds similarly striped crustaceans live without fear of detection; here we found the same sea-lily giving secure shelter to sea-worms, banded yellow and purple like itself."—(*A Naturalist in Indian Seas.* A. Alcock, London, p. 112, 1902.)

The association last mentioned in this passage, that between stalkless crinoids and a multitude of smaller invertebrates, forms the subject of this paper. To those who only know the species of *Antedon* found in our own British waters, the wealth of numbers and the riot of colour in the crinoid fauna of a tropical coral reef is a remarkable revelation. In October 1913, during my visit to Murray Island, I was able to observe this fauna under the best conditions. The commonest species there is the form *Comanthus annulatum* (Bell), remarkable for its extraordinary range of colour variation from very light-coloured individuals (in which white, light green, yellow, and grey mingled in the colour scheme) to others which are entirely dark green or black. In the shelter of its arms live commensal forms belonging to many groups of marine invertebrates, and generally speaking they possess a type of colouration which makes them inconspicuous upon the host and so varies with the colour of the host. The fact that such a relation exists between crinoids and such animals as alpheids, galatheids, and worms has been pointed out by Dana, Haswell, and Alcock, but I think the circumstances warrant the publication of a more minute though still very incomplete study of this curious phenomenon.

List of animals commensal with crinoids on the reefs of Murray Island and off Mabuiag, Torres Straits, Australia.

[Other forms described as commensals of crinoids in other areas are included in brackets. Only those forms which show colour resemblance to the host are included.]

CRUSTACEA	Decapoda Macrura Alpheidæ.	Synalpheus comatularum Haswell, S. brucei sp. n. (S. stimpsonii var. maldivensis, Indian Ocean. S. carinatus var. binongeensis, East Indies.)
	Pontoniidæ	Periclimenes commensalis Borradaile. P. pottsi Borradaile. [P. cornutus, ceratophthœlmus, brocketti, Indian Ocean.] [Pontoniopsis comanthi Borradaile.]
	Decapoda Anomura.	Galathea elegans Adam and White (G. deflexipons and longirostris are probably synonyms of this species). G. inflata sp. n. G. minuta sp. n.
	Isopoda	Cirolana lineata sp. n.
	Amphipoda	Cyclotelson gen. n. purpureum sp. n.
ECHINODERMATA.	Ophiuroidea	Amphiuridæ. Ophiactis sp.? Ophiotrichidæ. Ophiomaza cacaotica Lyman. Ophiomaza cacaotica var. picta Koehler. [Ophiophthirius actinometræ Döderlein, Torres Straits; Thursday Island. Ophioœthiops unicolor Brock, Amboina. Ophiosphæra insignis Brock, Amboina.
ANNELIDA	Polychæta	Polynoë minuta Potts var. comanthi var. n. [P. crinoidicola Potts, Indian Ocean.]
	Myzostomida.	
MOLLUSCA	Gasteropoda.	

DECAPODA MACRURA.

ALPHEIDÆ.

The species of alpheids commensal with crinoids in Torres Straits are two in number:

Synalpheus brucei sp. n. from *Comanthus annulatum* and *Comatula purpurea* on the reef at Murray Island.

S. comatularum Haswell from *Comanthus annulatum* in shallow water from localities in Torres Straits (Albany Passage, Cape York, and north of Mabuiag).

Coutière has divided the species of this huge genus *Synalpheus* into several groups, each consisting of nearly allied forms. In the *Comatularum* group those species are included which fall in the following diagnosis:

"Supraorbital spines insignificant compared to the rostrum; antennules shorter than the antennæ; spines of the basicerite almost equal, the external always smaller than the stylocerite; external maxillipeds oral, feebly spinous distally; first segment of the carpus of the second pair of feet very long, following feet cylindrical; ventral hook of the dactyl obsolete; telson with an oval median lobe."

Coutière goes on to remark that his group is—

"differentiated from the other groups by some marked characters, which are almost all characters found in the Hippolytidæ and therefore suggest a less strong resemblance to the Reptantia; as frequently happens, there are added to these primitive characters (others) which show on the contrary, an adaptation carried very far; for instance, the strongly curved hooks and the movable finger of the small chela surpassing the fixed finger; these characters are especially marked in *S. comatularum* and are explained by its commensalism with the comatulid, being implements of attachment for the *Synalpheus*."

Both the species which I have collected belong to this group. Moreover, two other forms which are included by Coutière are distinctly stated in the original descriptions as occurring on crinoids. These are: *Synalpheus stimpsonii* var. *maldivensis*, and *Synalpheus carinatus* var. *binongeensis* (from Comatula).

Thus, 4 out of the 12 species and subspecies in the group possess this habit. As, for the most part, the different forms are only known from very few specimens, and notes on the habits or even colouration of the living animal are hardly ever given, I think it highly likely that extension of our knowledge will show that the whole group is characterized by commensalism with crinoids and possibly also by the striking colouration, so different from that of other alpheids, which are found in *S. brucei* and *S. comatularum*.

Synalpheus brucei sp. n. (Plate 1, Fig. 2.)

A Synalpheus of medium size, commensal on crinoids. Body rather slender, colouration variable, with longitudinal bands of red or purple pigment. Rostrum very long, about one-third the length of carapace, reaching to the end of second antennular article, slender and acute, continued backwards for a short distance beyond the level of the eyes as a low carina. Supraorbital spines acute, about one-third the length of the rostrum. Antennæ (2) very long and slender; the basal joint hardly so long as the spine of the scaphocerite. Antennæ (1) very much shorter than antennæ; stylocerite only reaches to end of proximal article; proximal article much longer than other two; spines of basicerite almost equal, external does not extend further forward than supraorbital spine. Incisor process of mandible tends to end broadly, with several teeth. Large chela with rather inflated propodite, carpopodite with prominent spine on outer border. Meropodite with two smaller spines. Small chela with dactylopodite not stretching beyond end of thumb, meropodite with prominent spine on outer border. First segment of carpus of second pair of feet much longer than the four succeeding segments together. Third and fourth feet armed with sharp spine on inferior

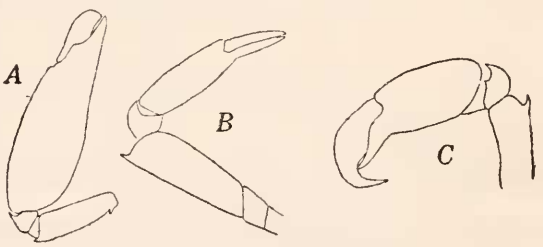

Fig. 1.—Chelæ of *Synalpheus*.
S. brucei: A, large chela, × 4; *B*, small chela, × 8.
S. comatularum: C, small chela, × 8.

margin of meropodite; dactylopodite with distinct ventral spike measuring about one-quarter the length of joint. Telson with anterior pair of spinules, rather slender, situated just behind halfway line; median lobe oval.

Locality: Murray Islands, Torres Straits.

Measurements: In seven females measured from the tip of the rostrum to the end of the telson the length varied from 1.9 to 2.8 cm. The eggs measured 1 mm. in length; with the growth of the embryo the envelope stretches and the egg becomes twice as long. They are always light green in colour.

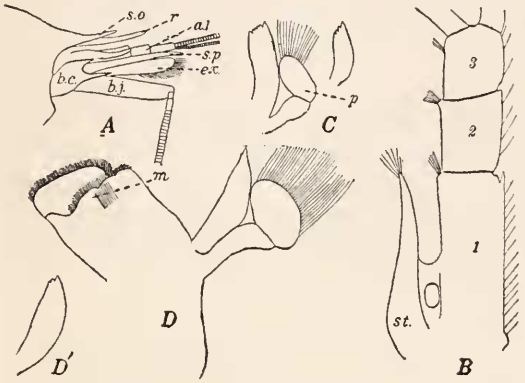

FIG. 2.—*Synalpheus brucei: A.* Lateral view of head showing antennæ and rostrum. *b.c.*, basicerite; *b.j.*, basal joint; *ex*, exopodite (scaphocerite); *s.p.*, spine of antenna 2; *a. 1*, antenna 1; *r*, rostrum; *s.o.*, supra-orbital spine. × 15.

B. Basal portion of antenna 1. *st.*, stylocerite; *1*, *2*, *3*, articles of protopodite. × 15.

C. Incisor process of mandibles in two individuals, one showing also palp (*p*). × 15.

S. comatularum: D. Mandible. Inset (*D'*) incisor process of another individual. × 15.

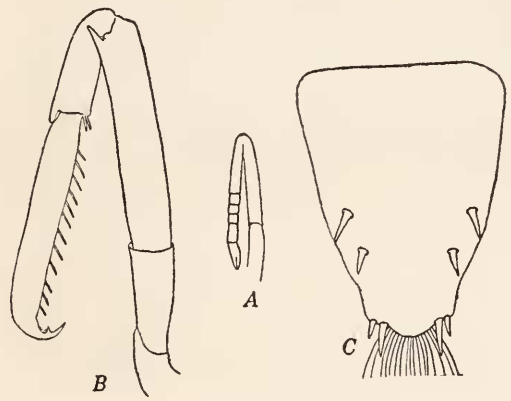

FIG. 3.—*Synalpheus brucei: A*, second pair of thoracic feet; *B*, third pair of feet, × 15; *C*, telson, × 15.

In these text-figures the corresponding structures of both *S. brucei* and *S. comatularum* are given for comparison in a few cases, as, for instance, the incisor process of the mandible, which, though variable in the number of teeth in both species (for this reason two examples of each are drawn to show the range) has a larger number in *S. brucei*.

RELATIONS OF COMMENSAL AND HOST.

Comanthus annulatum, with which *Synalpheus brucei* is usually associated, is very variable in colour. Some indication of this diversity is to be found in Dr. H. L. Clark's account of the Comatulids of Torres Straits. It will be sufficient here to say that the colouration varies from a light green mingled with yellow and white to the darkest green or even black. The commensal alpheid is generally black to brownish purple in ground-colour, but the pigmented dorsum is traversed by longitudinal stripes which are free from pigment. Of these one runs down the middle line from head to tail, there are either two or three on

each side of the carapace, and two on the upper surface of the chela. In addition, each abdominal pleuron is traversed by a short, oblique pigment-free stripe, which may by the encroachment of the pigment become a spot. The relative extent of pigmented and non-pigmented areas is exceedingly variable and corresponds roughly to the depth of colouration of the host which the alpheid inhabits. Individuals which lodge upon a light-green coloured crinoid have only thin red or purple lines of pigment, the rest being unpigmented; in those which are associated with a dark green or black host the pigment may be spread over the whole of the dorsum.

In the vast majority of cases a pair, male and female, of alpheids is found on each comatulid. In a few cases there appeared to be only a single lodger, but then its small size seemed to show that it was too young to have acquired a mate. In most cases the pair are similarly coloured; rarely, however, there is a difference, and I will mention one case in which one member was marked with very definite and fairly wide stripes of dark pigment, while the other was uniformly covered by red pigment.

There are two factors in colour variation. The one is the character of the pigment, which ranges from a clear red to a purple so deep as to appear black. The second depends on the area of the body covered by the pigment. The former factor seems to depend very largely on the species of the host. *Synalpheus brucei* is found (though more rarely) on a second host, *Comatula purpurea*, in which reddish pigment predominates, and here the crustacean was sometimes observed to show a red pigment which covers the whole body and thus matches the host. But sometimes purple and white striped individuals are found on *Comatula purpurea*, thus transgressing the apparent needs of the species.

Among the commensals of *C. annulatum*, too, the pigment may be red or red brown. But this is only so in the cases where the coloured stripes are narrow. Where they are broader the pigment is invariably darker. The chief variations of colour, then, may be tabulated as follows:

Uniformly red-brown	In *C. purpurea.*
With narrow red stripes	In light-green varieties of *C. annulatum.*
With purple stripes or uniform dark colouration	In dark-green varieties of *C. annulatum.*

The purple pigment would seem to be either something additional or a more complex product of the red pigment. In alpheids which were preserved in formalin and glycerin to keep the original colour as far as possible, the purple was speedily lost, leaving such a red as occurs in the lighter-coloured forms.

Synalpheus brucei thus exhibits a marked protective resemblance to its host. Against the very light-coloured crinoids the almost colourless alpheid is quite inconspicuous. The striped specimens are found upon crinoids where bars of light and dark pigments alternate, and so they

too are not easily seen. And lastly, when the dark pigment is uniformly spread over the body of the crinoid this is also the case with the alpheid.

But though this is often true, there are many cases where the resemblance is by no means close and the alpheid is rather conspicuous. I am inclined to explain these cases by supposing the alpheids to have migrated from some other crinoid at a comparatively recent period. So thickly do the crinoids lie in the crevices of the reef, all conceivable colour-varieties being herded together without distinction, that it is more than likely that an interchange of commensals should occasionally take place; for *Synalpheus*, though tending to become a truly sedentary animal, is at times very active and an excellent swimmer. I should also like to suggest that the conditions of commensalism do not allow natural selection to come into play to any marked extent. The commensals are for the most part inclosed by the arms of the crinoid as in a living cage. When the water is calm these arms are relaxed and extended, but on the approach of an intruder they curl up and so protect the soft central disc. It is hardly to be supposed that even a rapacious fish would take a mouthful of these hard and unsatisfying arms for the sake of the shrimp which lies amongst them. In no case at least which we saw were the arms of crinoids mutilated.

Gamble and Keeble have shown that in the prawn *Hippolyte* the young larva is at first a colourless creature living at the surface of the sea, and when this is carried inshore it attaches itself to the first seaweed it meets. The skin is in such a sensitive condition that within a week a complete resemblance in colour is brought about, whether the seaweed background be red, green, or brown. It seems that the resemblance in colouring of *Synalpheus* to its host is a similar phenomenon. But it is less perfect because natural selection has not been brought into play to the same extent (if at all) as in *Hippolyte*, whose seaweeds offer it a holdfast but not a complete refuge such as the crinoid affords.

Generally, both members of a pair are similarly coloured. This is a phenomenon which may be explained in two different ways. Either mating takes place early, before the pigment pattern has been finally determined, and the same causes act equally on both, producing a similar pattern, or else there is assortative mating. Possibly the truth lies in a combination of both explanations. If so, the exceptions where mates are dissimilarly coloured are due to the breaking down of the rule of assortative mating or the existence of individuals which are not able to assimilate themselves to their background.

With regard to the habits of *S. brucei*, it is usual to find the male and female lying side by side on the surface of the disc, but when disturbed they take refuge between the pinnules or on the aboral surface of the arms. They thus move about quite freely, but they can guard against forcible detachment by digging the claws of the thoracic legs into the

soft flesh of the disc or by clasping the pinnules or arms of the crinoid. The chelæ are less effective for maintaining a hold than the thoracic legs, but it is to be noticed that these can not be said to be specially modified for this purpose. They are provided with two sharp claws, but this provision is also made in cases where the alpheid has no such commensal habits.

When removed from the crinoids they swim about very rapidly, but return as soon as possible to the shelter of the host, and cling to it as before. They exhibit reactions to light and touch in a very marked manner. Alpheids placed in a glass vessel always cluster together on the side of the vessel opposite from the light. Besides being negatively heliotropic, they are strongly thigmotropic, for when the finger is introduced into the water it is instantly embraced by the thoracic legs of the alpheid. In the absence of any foreign object, the alpheids embrace one another, so that a number left together in a vessel soon look like a mass of swarming bees.

There seems to be a limited faculty of colour change. One individual with wide stripes of pigment became lighter toward night, darker again at day. Unfortunately I did not make any extended observations on this point.

Synalpheus comatularum (Haswell). (Plate 1, Fig. 1.)

Alpheus comatularum, Haswell, Proc. Linn. Soc., N. S. Wales, vol. 6; Catalogue of the Australian Stalk and Sessile Eyed Crustacea, Australian Mus., pp. 189–90.

This species was dredged in a few fathoms of water in Albany Passage, near Cape York, during the cruise of H. M. S. *Alert*. "They were invariably found clinging to the arms of a species of comatulid to which their markings gave them a general resemblance." It was also obtained during the voyage of the *Challenger*, in neighbouring waters and off Ceylon, by Professor Herdman.

We did not find this form at Murray Island, but during a visit to the western Islands of Torres Straits, in the early days of November, I obtained it in 3 to 5 fathoms off the great reefs lying north of Mabuiag Island. With the greatest kindness, Mr. Walker, managing director of the Papuan Industries Co., Ltd., put the company's schooner *Dogai* at my disposal and, with three divers from Badu in addition to the ordinary crew, I spent a couple of days on the Mabuiag pearling grounds. For an hour or more at slack tide the most wonderful crinoids were to be collected by diving. The species so common at Murray Island (*Comanthus annulatum*) was the dominant form here, but represented by individuals even larger and more splendid in colour than those inhabiting the reefs of the Murray Islands.

S. comatularum is markedly larger than *S. brucei* and is stouter in general appearance. But the resemblance in colouration and habits is so close as to suggest specific identity until the peculiar form of the

little chela is noticed. It is this feature which distinguishes the type species from all the others included in the *comatularum* group. The thumb is much longer than its unmovable fellow and forms a strong recurved hook, by means of which, Haswell remarked, it clung to the arm of the crinoid. The individuals taken on the *Dogai* were generally seated in pairs on the disc, like *S. brucei*, but when slightly disturbed they immediately dug the hook of this chela into the flesh of the disc, from which it was only dislodged with difficulty; or if the alpheid had left the surface of the disc, the chela was serviceable for clasping the arm of its host. But this instrument is only used for temporary attachment, nor is it usually embedded in the host when the animal is at rest.

The wonderful similarity in colouring between the two species of *Synalpheus* is noticed above. There is, however, one marked difference; that is, the entrace of a white or yellow pigment into the colour scheme of *S. comatularum*. A typical example of a light-coloured crinoid and its commensal may be briefly described here.

The crinoid (*C. annulatum*) had a yellow-green disc, the arms were black with white tips, sometimes with a dash of rusty-red pigment, and the pinnules white, sometimes grey at the side. The underside of the arms was yellow-green and the cirri were white. Both the commensals were light coloured and harmonized to a considerable extent with the host. The female had five prominent lines of white pigment on the thorax alternating with brown lines; in the abdomen there was a median white line with a brown line on each side, most of the median space being colourless and a non-pigmented eye being found on each pleuron. The male showed 6 lines of brownish-purple pigment on the thorax, all else being colourless, save for some dashes of white pigment. In this case the two partners differed slightly; the female showed well-developed white pigment and the other pigment was brown; in the male white pigment was almost absent and the pattern was formed by a purple-brown darker than in the female.

PONTONIIDÆ.

Three prawns of this family, all new to science, were found to be characteristic members of the crinoid fauna. These are: *Pontoniopsis comanthi*, *Periclimenes pottsi* and *P. commensalis*. They have all been examined by Mr. L. A. Borradaile and full diagnoses have appeared in his recent revision of the family. I will confine myself here to giving the details of their colouration and habits which were noted.

Pontoniopsis comanthi Borradaile.

This was found only at Mabuiag on the light-coloured varieties of *Comanthus annulatum* in which a great deal of green pigment had developed. In general this small crustacean (it is about 8 mm. long) exhibits a striking correspondence with its host. Alternate longitudinal stripes of bright green and black or dark brown occur on the dorsum, and these match with the crinoid cirri, in which green and yellow alter-

nate with dark green or black. There also occurs another variety, in which the green pigment is replaced by yellow and the darker pigment by red or brown. In the specimen figured (pl. 1, fig. 3), which is typical of the species, there were three yellow stripes alternating with two brown of equal breadth. The chela was yellow with a brown line. In this case, however, the commensal, living on a crinoid in which green predominated, was very conspicuous, and I suppose it to have developed its pigment in association with another crinoid of different colour type.

Periclimenes pottsi Borradaile.

This shrimp is comparatively common on the crinoids from the Murray Island reef, but only one or two specimens were obtained at Mabuiag. It is a very transparent creature, and though the general colouration, a beautiful purple, harmonises with the host, there is no distinct arrangement in longitudinal stripes. The low power of the microscopes shows that there is a blue pigment contained in very numerous small cells which are regularly disposed over the body. Also evenly distributed, but much fewer in number, are cells containing red pigment. These may be spherical or branching. The gut is coloured red. The general effect is thus purple.

Periclimenes commensalis Borradaile.

I did not, amongst the living specimens, distinguish this species from *P. pottsi*, so probably what has been said about the latter species also applies to the former. It may be noticed that these are not the only species of the genus *Periclimenes* to be found in association with crinoids. Others are *P. cornutus*, *ceratophthalmus*, and *brocketti*, all found on crinoids from the Maldives, as noted by Professor J. Stanley Gardiner.

Information about the surroundings of the animals so seldom accompanies general collections that I fully expect a similar connection to exist in the case of many other species of this enormous genus.

DECAPODA ANOMURA.

GALATHEIDÆ.

There are at least three species of galatheids commensal with crinoids in Torres Straits. These are: *Galathea longirostris* (= *G. elegans*), *G. inflata* sp. n., *G. minuta* sp. n. These are all small forms from 6 to 15 mm. in carapace length and are dark coloured with longitudinal, pigment-free bands, a colour scheme corresponding almost exactly to that of the alpheids. They are not by any means found so commonly as is *Synalpheus*, though *G. longirostris* is not infrequent. My observations do not lead me to suppose that the galatheids occur in pairs on each host, but the absence of evidence on this point may be due to the fact that they are inclined to leave the host whenever disturbed. There is no special modification for clinging to the crinoid

other than the spines on the dactyli of the thoracic legs, but the animals are thigmotropic and swim back immediately to the host when they have been detached.

Galathea elegans Adam and White. (Plate 1, Fig. 5.)

G. elegans, Adam and White, Voyage of the *Samarang*.
G. longirostris, Dana.
G. deflexipous, Haswell, Proc. Linn. Soc. New South Wales, vol. vi; Miers, Zool. Coll. H. M. S. *Alert*.
G. longirostris, Southwell, Anomura, Ceylon Pearl Oyster Rep. Roy. Soc., part V, p. 220, 1906.

In earlier literature there are only three records of the occurrence of galatheids on crinoids. The first is that of Dana, who originally described *G. longirostris* from a crinoid dredged at Fiji; the second is that of Haswell, who founded a new species *G. deflexipous*, associated with *Synalpheus comatularum* on an unidentified crinoid. The third likewise concerns *G. longirostris*, which is mentioned by Southwell as obtained near Ceylon, clinging to *Antedon bella*.

G. elegans Adam and White, *G. longirostris* Dana, and *G. deflexipous* are all very closely related. They all possess a long rostrum with from 5 to 10 small lateral denticles, a very typical dorsal ornamentation, and have a similar colour scheme, with longitudinal stripes of pigment on the dorsum. The first-named species has not been noted as occurring on crinoids, but this may be the fault of the collectors. Balss, in describing a specimen from Japan, which he assigns with some doubt to *G. elegans*, says with regard to its occurrence: "Waheschеinlich an Comatuliden, wie es Haswell von der nahe verwandten *G. deflexipous* und Southwell von *G. longirostris* Dana angeben. Darauf weist die bunte Färbung hin, die wohl als eine mimetische zu deutenist." Probably the whole group of related species are crinoid dwellers. If not, it will be strange that so marked a pattern should occur on a free-living galatheid, when that is a character so definitely associated with crinoid commensalism, both here and in other groups.

The three species are principally defined with regard to the characters of the rostrum; thus:

G. elegans:	*G. longirostris:*	*G. deflexipous:*
Rostrum more than half the length of the rest of the carapace, "with 7 small denticulations on each side" (Haswell). But Balss gives the latter number as 9. But most important of all, the original figure only shows 5 or 6.	Rostrum fully as long as half the carapace "minutely 5–6 serrulate."	Differs from *elegans* only in the fact that the rostrum is entirely deflexed.

With regard to the third species Miers says:

"In more than one of the specimens in the Museum collection the rostrum is slightly deflexed, and I think that *G. deflexipous* Haswell, from Albany Passage, should be regarded merely as a marked variety of *G. elegans*."

In my own specimens the number of denticulations on each side is from 6 to 7; in one individual there were 6 on one side, 7 on the other.

There are also a number of cases in which the rostrum is deflexed. From the comparison here made and the facts stated I think there is little doubt that we are dealing with one very variable species.

I have compared my collection with the full description given by Balss of his specimen (the fullest description given of *G. elegans*) and find the following discrepancies:

(1) In the third maxilliped the merus is armed with three prominent spines on the internal border in the Japanese form, in mine with only two; Henderson and Ortmann both describe *G. elegans* with two spines in this position.

(2) In the ambulatory limbs the merus has a spinose upper angle according to Balss, but is smooth in the Torres Straits forms; the denticulation of the dactylus is weak in the former, but in the latter there is a powerful end claw, succeeded by prominent teeth only gradually decreasing in size.

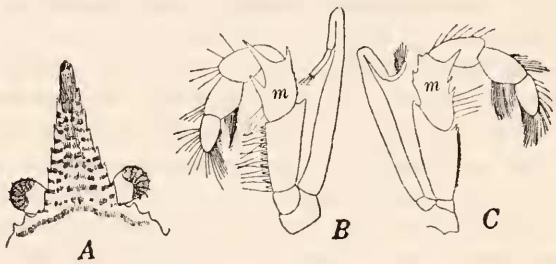

FIG. 4.—*Galathea.*

A. *G. elegans*, Torres Straits, rostrum showing lateral teeth and arrangement of hairs. × 8.
B. *G. minuta*, third maxilliped, showing spines on merus (*m*). × 18.
C. *G. inflata*, third maxilliped. × 4.

But in a variable species we might expect to find such differences. The Japanese form described by Balss is clearly a rather extreme member of the variable series, as shown by the fact that it has the highest number of denticulations on the rostrum recorded. The agreements between Balss's description and my specimens outweigh the differences.

In conclusion, I give the following diagnosis, to embrace all the forms here discussed:

G. elegans: Rostrum rather more than half the length of the remainder of the carapace with from 5 to 9 small denticulations on each side; width about half the length; sometimes deflexed; carapace somewhat pear-shaped; about a dozen indentations on each side; surface traversed by many narrow horizontal furrows, from which spring thick lines of short fine hairs, though these may be absent or nearly so. The rostrum is covered with hairs rather longer than those on the carapace, arranged in distinct crescents posteriorly. Dorsum and limbs covered with dark pigment, but there are generally pigment-free longitudinal bands of variable width. Chelæ long and slender, cylindrical in section, thicker in the male than the female, varying in length in the latter.

Often, if not always, commensal with crinoids.

Measurements of Torres Straits specimens (a female with eggs): Length of carapace 11 mm.; maximum breadth 6 mm.; length of rostrum 4.5 mm.; length of chela 15 mm. (of propodite 7 mm., carpopodite 2.5 mm., meropodite 5 mm.)

Another small male: Length of carapace 6 mm.; breadth 3.5 mm.; length of rostrum 2.5 mm.; of chela, 9.5 mm. (propodite 4, carpopodite 1.5, meropodite 4).

So far as I can find, there is no description of *Galathea elegans* White, but only the figure. From this, however, I think it is possible to assert its community with the other forms under discussion. Balss queries his Japanese individual because its chelæ are more slender and longer than those in White's drawing and because the width of the colour bands is different. In my Torres Straits collection, as I have repeatedly observed, the width of the bands is a variable feature, so the latter point need not trouble us. The discrepancy of the chelæ is likewise to be explained by variation and possibly, to a certain extent, by the draughtsman's error.

I have taken the opportunity of comparing my series with a specimen obtained by Dr. Willey in New Britain and identified by Mr. L. A. Borradaile as *G. elegans*. This certainly differs distinctly from the commensal of *Comanthus* in the following particulars: It has a broader but rather shorter rostrum with more (9) lateral denticles. The eyes are larger, the transverse furrows on the dorsum not so well developed, hairs are almost absent on the greater part of the carapace but present on the rostrum. Here they are arranged in just the manner characteristic of the animals from the Torres Straits. This individual seems to come nearer to that described by Balss from Japan.

Galathea inflata sp. n. (Plate 1, Fig. 7.)

A small galatheid with rather broad and swollen carapace narrowing considerably anteriorly; rostrum of medium length with 3 sharp spines on each side; carapace with very few hairs, gastric region without spines, anterior transverse ridges broken up and surface covered with scales. Merus of third maxilliped with 3 spines internally, 2 externally. Merus of ambulatory limbs with about 9 spines on upper border.

Commensal with crinoids, Murray Island, Torres Straits.

With eggs, length of carapace to tip of middle spine on rostrum, 7 mm.; breadth 5 mm.; length of rostrum 2.5 mm.

The carapace is traversed by only 7 or 8 traverse grooves, but posteriorly incipient grooves make their appearance between the complete ones at the lateral extremities of the segments. The cervical groove is deep and continuous; on each side of it the traverse ridges are broken up into prominent scales. The external border of the cephalothorax has about 7 strong spines on each side.

The rostrum is broad and of medium length. The central spine is long and stout; on each side are two others, almost as well developed, and a third at the level of the eye which is shorter and weaker. The surface is covered with small scales.

The basal joint of the first antenna is provided with 3 spines, the dorsal of which is longer and stronger.

On the merus of the third maxilliped there are internally 3 spines, the middle one being the shortest; externally are 2 very blunt spines; the teeth on the inner border of the ischiopodite are small and numerous.

The chelæ are missing in this specimen. The ambulatory limbs are rather thickly beset with long coarse hairs; spines on the merus not very well developed, but spines on the carpus very prominent. Dactylopodite with strong spine after end claw, others small.

Colouration: Dark-blue pigment on carapace, with two fairly broad longitudinal pigment-free bands.

On *Comanthus annulatum* were a few very small galatheids, white in colour, with rather thin and membranous cuticle. Two which were examined in detail were females with eggs and could not have moulted very recently. In these the form of the rostrum comes very close to *G. inflata*. It is short and broad, armed with 4 spines on each side, of which the 3 anterior are prominent, almost as large as the median spine, and the fourth is much smaller. They differ from *G. inflata* mainly in the fact that the median spine is the same size as those which follow instead of being distinctly larger. The rostrum is covered by coarse hairs. The carapace is traversed by transverse grooves, but in one specimen (the larger) these are broken up at the side into rounded scales, while in the other the lines run interruptedly across. The carapace is not pear-shaped, as in *G. inflata*. In another point the two individuals differ considerably, that is, the development of the third maxilliped, which in the larger form possesses 2 spines on the inner side of the merus and some very small blunt processes on the outer border. In the smaller form (which was parasitised by a bopyrid) there is only a single spine on the inside, while the outside is smooth.

It seems possible that we are dealing with a variable species or possibly a group of species which has the rostrum character described above, while the carapace shape and to a certain extent its ornamentation varies with the size of the individual. The character of the third maxilliped is also variable, the number of spines on the merus increasing with age.

With regard to the strong development of pigment in one and its non-appearance in others, in spite of the fact that all were found on crinoids, I can make no suggestion of any importance. It may be that in a variable species some individuals are incapable of an assumption of pigment. It is not to be supposed, I think, that these unpigmented individuals had but recently taken up their residence in the crinoids, for they were mature females with eggs. However, I can not pretend to explain, on the strength of only three specimens collected, a phenomenon which is of so much biological interest.

For the present, then, I wish to recognize an "*inflata*" group, distinguished by the short, broad rostrum with 3 or 4 spines on each side (of

which the last is the smallest) and the absence of spinulæ on the gastric region. They differ from *multilineata* in having a shorter rostrum and longer spines and in the far less marked sculpturing on the carapace.

Galathea minuta sp. n. (Plate 1, Fig. 6.)

A very small galatheid, with short and broad rostrum, 3 sharp spines on each side; gastric region without spines, carapace with few hairs, traversed by about 12 shallow transverse grooves; chelæ short; merus of third maxilliped with 2 strong spines internally, one externally.

From *Comanthus annulatum*, obtained in about 4 fathoms of water off Mabuiag Island, Torres Straits, Australia.

Measurements: Length of cephalothorax to tip of rostrum 4.5 mm. Length of chela 6.2 mm., of propodite 2.7 mm. Breadth of cephalothorax 3 mm. Length of carpopodite 1.0 mm., of meropodite 2.5 cm.

The carapace is of fairly uniform breadth, narrowing slightly and gradually anteriorly. Its surface is smooth, traversed by only about 12 shallow grooves, in which lie scanty rows of short hairs. There are no spines on the gastric region, but prominent spines (8 in number) exist at the end of the transverse grooves.

The rostrum is rather short and broad. The central spine is very strong and elongated and on each side of it are 3 prominent spines with their bases close together and advanced, also strong and elongated. The surface is smooth.

The basal joint of the first antenna carries 3 anteriorly directed spines; the dorsal one is long, the two ventral smaller and more slender.

The merus of the third maxilliped carries 2 large spines internally and one, rather shorter, externally followed by small spinulæ. The teeth on the internal border of the ischiopodite are comparatively few and strong.

Abdomen with two transverse lines to each segment.

Chelæ short, about half as long again as the cephalothorax, beset with long, coarse, scattered hairs and strong spines on the propodite, carpopodite, and meropodite, especially the carpopodite. Dactylopodite little more than a third of the propodite in length.

Merus of ambulatory legs beset on upper angle with about 10 spines, very small proximally, prominent distally. Dactylopodite with strong end claw and one prominent spine succeeded by minute processes.

Colouration: Alternate longitudinal stripes of white and dark blue, as shown in plate, of about equal breadth. On a light-coloured individual of *Comanthus annulatum*.

AMPHIPODA.

A tiny amphipod which occurred very often on the darker crinoids is apparently to be referred to the family *Amphilochidæ*, a new genus of which must be established for its reception.

CYCLOTELSON gen. n.

Rostrum curved, acuminate, lateral angles of head rounded. Side plate 1 not much smaller than 2, rounded, obscured by those succeeding it; 2 to 4 large and deep, 2 and 3 rounded, 4 largest, quadrangular shape (also 5) as in *Amphilochus*. Antenna 1 very short and stout, flagellum particularly so. No accessory flagellum, upper lip bilobed, lower lip with small inner lobes. Mandible with very narrow denticulate cutting edge, molar process absent, third joint of palp very long. Maxilla 1, inner plate absent, outer plate with 8 or 9 spines, the proximal much the largest and forming dentate process

pointing inwards; palp very broad, 2-jointed. Maxilla 2 normal. Maxilliped inner plate elongate, palp rather long. Gnathopods 1 and 2 similar, nearly the same size, subchelate, palm not so long as in *Amphilochus*, broad, distal edge rather oblique, broadest part of palm, finger with sharp spine under apex. Peræopods 1 to 5 slender, 3 to 5 with second joint expanded. Telson comparatively broad with rounded termination. Lateral angles of last abdominal segment as long as telson itself.

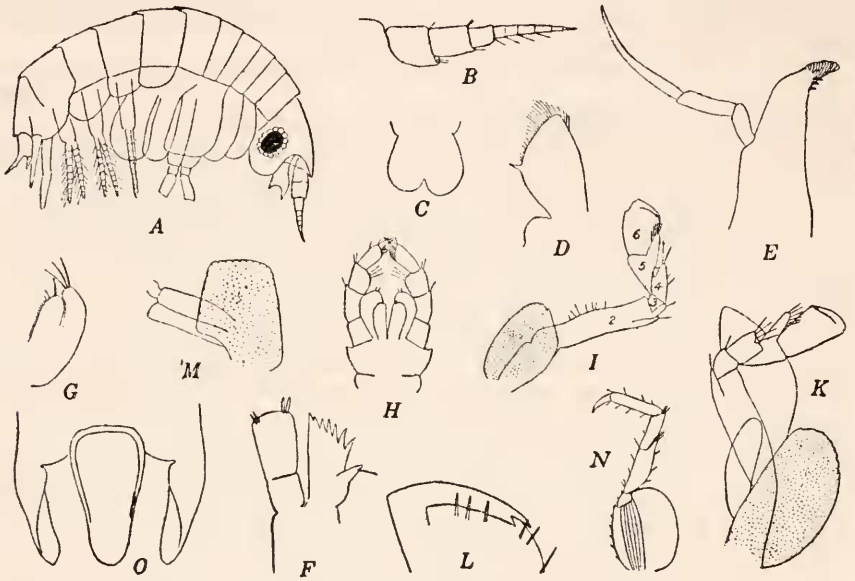

FIG. 5.—*Cyclotelson purpureum* gen. et sp. nov.

A. Whole animal, lateral view. ×17.
B. Antenna 1. ×52.
C. Upper lip. ×225.
D. Lower lip (half). ×225.
E. Mandible. ×130.
F. Maxilla 1. ×130.
G. Maxilla 2. ×130.
H. Maxilliped. ×52.
I. Gnathopod 1. ×52.
K. Gnathopod 2. ×52.
L. Gnathopod 2: finger and anterior edge of palm. ×225.
M. Side plate 4 with first joint of peræopod 2. (Lateral plate dotted.) ×30.
N. Peræopod 4. ×30.
O. Telson and lateral angles of last abdominal segment. ×130.

Cyclotelson purpureum sp. n.

Side plates vary in serration of lower and posterior margins: 1 with single serration, 2 with about 10, 3 and 4 with many. Antenna 1 six-jointed with very few sensory setæ, no appreciable difference between male and female. Antenna 2 incomplete in specimens examined, but from width of basal joints seems to be distinctly larger than 1. Outer lobe of lower lip with fringe si-setæ and an inwardly directed spine. Mandible with third joint of palp dot tinctly longer than 1 and 2 combined, no setæ on palp; three small spinules under incisor process. Gnathopods 1 and 2, sixth joint widens gradually of form a convex palm with slightly oblique anterior edge; finger stout, equal in length to front edge of palm, minute serrations behind subapical spine; fifth joint produced to about middle of the palm, process broad; second point produced slightly. Telson width more than half length, apex rather rounded.

Colour, purple on dorsum. Lives on crinoids. *Comanthus annulatum*, Murray Islands, Torres Straits.

ISOPODA.

Cirolana lineata sp. n. (Plate 1, Fig. 4.)

This species comes under the second section of the genus as divided by Hansen,* in which are included all species with the following characters:

"Lamina frontalis inermis, lata brevis, pentagona (varius fere hexagona), vix dimidio longior quam latior.

"Clypeus inermis, non cornutus, ante perspicue cum lamina frontali conjunctus.

"Antennulae pedunculo obscure triarticulato (primo visu biarticulato) flagello semper satis gracili.†

"Pedes omnes setis perpaucis vel nullis instructis."

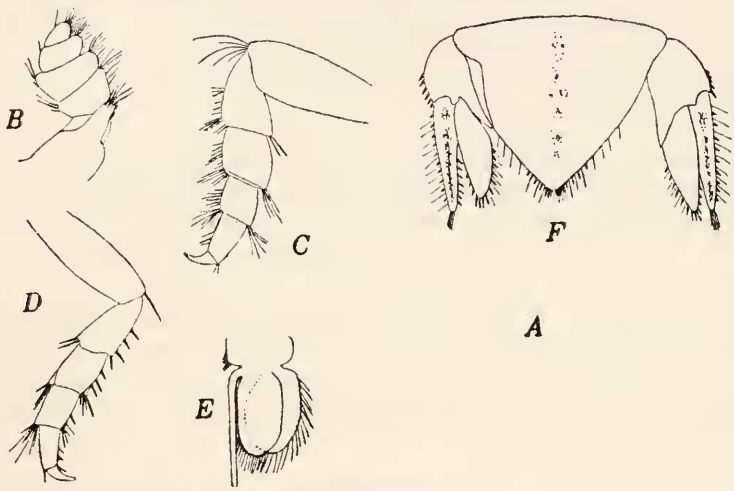

FIG. 6.—*Cirolana lineata* sp. n.

For whole animal see plate 1, fig. 4. All figures except E are of the female.

A. Antennæ and frontal lamina.‡
B. Maxilliped. ×38.
C. Sixth thoracic leg. ×18.
D. Seventh thoracic leg. ×18.
E. Second pleopod of male, showing appendix masculina. ×18.
F. Telson and uropods. ×18.

Diagnosis: A small cirolanid, body ovate (female), rather more than twice as long as broad. Measurements, female 6 mm. in length, 2.5 mm. in breadth; male 4.7 mm. in length, 1.5 mm. in breadth. Occurs on crinoids, generally *Comanthus annulatum*, in Torres Straits. Colour white except, for branding chromatophores carrying a purple pigment and arranged in two lateral stripes and a fainter median line.

Head wider than long, anterior margin rounded. Eyes of medium size. First antenna stout, first joint of peduncle large, second a little smaller, and

*Hansen: Cirolanidæ et familiæ nonnullæ propinquæ Musei Hauniensis. Kjobenhavn. 1890. See p. 336.

†But I take exception to the definition of the peduncle as always so obscurely triarticulate; and the condition of the peduncle in my species seems to resemble that in *C. parva* established by Hansen, which from the figure is clearly triarticulate.

‡The duties of the author as an officer in the British Army, prevented his attention to this paper as it was going through the press, and figure A was unobtainable.

third much smaller; flagellum composed of about 8 joints. Second antenna more slender than the first but not very much longer; in the peduncle the first two joints are very small and equal; the third is as long as the first two together, the fourth longer still, and the fifth about as long as the third; the flagellum is composed of 7 joints and extends very little beyond the lateral margin of the first segment. The frontal lamina is pentagonal, scarcely twice as long as broad.

Maxilliped second joint much longer than those succeeding, which are very broad. First thoracic segment nearly twice as long as the second; the posterior six segments vary slightly among themselves. Appendages robust, all joints broad, with few setæ.

First segment of abdomen quite hidden below last thoracic. Telson forms an equilateral triangle, ending in a sharp apex with 16 to 18 spines on the posterior margin, surface smooth. Inner ramus of uropod extends a little further than the telson, is narrow and ends in a sharp apex; both margins are furnished with spines; outer ramus about the same length, but still narrower; peduncle not produced far posteriorly on inside.

Appendix masculina slender, much longer than inner ramus of second uropod, apex rounded.

This species is very distinct. It is separated from all others by the insignificant length of the second antenna, and also, so far as I can find from the published descriptions, by the character of the colour markings. The shape of the telson and especially of the uropods is also very distinctive.

All the members of the Cirolaninæ to which this species belongs are predatory and swim about very actively. *Cirolana lineata* is far from being as sedentary as *Synalpheus*, which, while very energetic at times, rests for long periods on the disc of the crinoid. While the isopod may make busy excursions onto the surface of *Comanthus*, it is often to be seen diving into the gut of the host, where it apparently spends a large part of its time. It does not feed, so far as I know, on the tissues of the crinoid itself, but only on the food it finds in the stomach.

It must be this or a very closely related form which Haswell refers to as collected from a crinoid in Torres Straits associated with *Synalpheus comatularum* and *Galathea deflexipous*, but no identification of his isopod seems to have been made.

This case of commensalism is interesting because of the faint but significant response to the colour stimuli of the crinoid. In nearly all the species of this genus, where the colouration is noted at all, the chromatophores appear to be distributed over the surface so as to form a series of evenly spaced dots or dashes of pigment. The concentration of these into lines and the development of a purplish pigment seem to be the first effects of the commensalism. The insignificant quantitative development of the pigment is probably associated with the very active life of the isopod and its frequent immersion in the gut of the host, rather than to any incapacity of the isopod to assume the colours of the environment.

ECHINODERMS.

The only echinoderms which were found associated with the crinoids were ophiurans, and of these only one genus (*Ophiomaza*) is characteristically commensal. A small species of *Ophiactis*, which seems to be as yet undescribed, and a young *Ophiocoma*, too small for accurate determination, were found on *Comanthus annulatum*, but it was not possible to determine whether this association was anything more than accidental. But of *Ophiomaza* a sufficient number of specimens was found to show that that genus is normally commensal. All the individuals taken were on comatulids; none were seen elsewhere. On *Comanthus annulatum* were found specimens of *Ophiomaza cacaotica*, uniformly black (or very deep purple or brown); *O. cacaotica* var. *picta*, prettily marked with black and white; and *O. obscura*, brown, handsomely marked with dull yellow. In all these cases, a certain amount of correlation between the colour of the ophiuran and the colour of the host was obvious. But on a bright red *Comatula purpurea* was found a small black specimen of *O. cacaotica*, and of course the colour contrast was very striking. However, *Ophiomaza* was much too rare to permit any reliable deductions to be drawn concerning the influence of commensalism on the colouration.

POLYCHÆTA.

Polynoë minuta Potts var. oculata var. n.

This polychæte, which I found rather frequently on the darker varieties of *Comanthus annulatum*, undoubtedly comes nearest to *Polynoë? minuta*, which I described in 1910 from specimens collected by Professor J. Stanley Gardiner in the Maldives.* It was not stated that this form

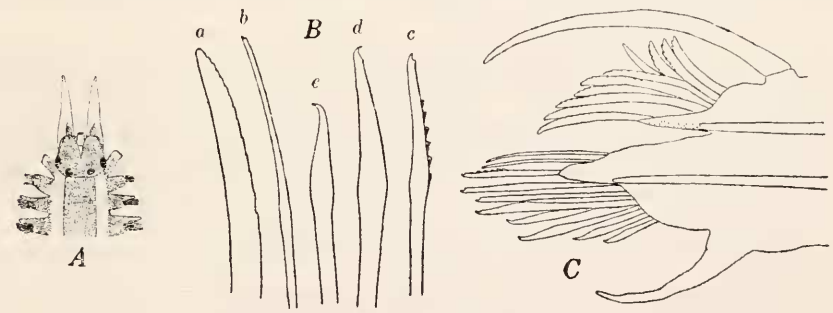

Fig. 7.—*Polynoë minuta* Potts var. *oculata* var. n.

A. Head and anterior part of dorsum to show colour pattern; median tentacle, tentacular cirri, and dorsal cirri all wanting. ×8.
B. Setæ. *a*, dorsal; *b–e*, ventral.
C. Parapodium of sixth segment. ×65.
References in text: *A*, *B*, *C*, ×163; *D*, *E*, ×280.

occurred upon crinoids, although the labels of the various specimens of *P. crinoidicola*, in the same collection, gave quite definite information

*Trans. Linn. Soc., London, vol. xiii, pt. 2, Polychæta of the Indian Ocean; pt. ii, The Palmyridæ, Aphroditidæ, Acœtidæ, and Sigalionidæ. See p. 337.

of such an association in this latter case. As we do not know whether the original species is a commensal of crinoids, and in view of certain morphological discrepancies, I describe the Torres Straits form as a new variety.

The two cotypes of *P. minuta* were incomplete individuals and on this account the generic ascription was queried. In the series under consideration there are three complete individuals, each having 15 pairs of elytra. There is no reason why this species should not be definitely assigned to the genus *Polynoë*, though there is good reason for undertaking a revision of this and kindred genera.

The characters which separate the Torres Straits form from the original species are as follows:

(1) The head is provided with two pairs of very distinct eyes, the one placed laterally near the posterior angle, the other on the posterior border. The head is covered with dark pigment, but there is a pigment-free ring round the posterior eyes (the depression separating the two lobes of the head is free also). In the Maldivian individuals there were no signs of eyes.

(2) The lateral tentacles have a much swollen base—in the type species they are thin throughout. The lateral anterior angles are rounded instead of slightly pointed. The palps are rather longer in proportion to the size of the animal.

There are a number of additional points, some of which could not be mentioned in the original account, which are treated below:

Colouration: The dorsum, with the exception of 2 longitudinal pigment-free bands, is covered by dark brown pigment, not soluble in 70 per cent alcohol. The markings are hidden by the elytra, which are uniformly pigmented.

Shape: In smaller specimens tapering rather abruptly, in a larger one of uniform breadth up to end.

Number of elytra: Fifteen. They cover almost the entire dorsum.

Setæ of neuropodium: These fall into the following categories: (1) Very long and slender, long drawn-out head slightly enlarged, ending in a blunt apex with a projecting tooth of almost equal size underneath (type B). (2) Thicker, head more pronounced, sharp incurved apex with prominent tooth underneath; one or two of the dorsalmost often have prominent spines on the convex surface of the head (C). Ventrally, however, spines are never present (D) and they pass into (3) a still stouter type with shorter head, apex still more incurved, tooth not so prominent (and in the ventralmost altogether absent (E)).

This succession of setæ is almost identical with that in *P. minuta*, as I find on comparison with the type specimens, which I did not describe with sufficient fulness in 1910. Setæ of type 1 occur there, though they were not mentioned or described; the other types were given, and the only difference is the absence of setæ with a very definite row of spines in *P. minuta*.

Measurements: Those of three complete individuals are given:

Specimen.	Length.	Breadth, including parapodia.	No. of segments.
	mm.	*mm.*	
A.....	10	2	50
B.....	8	1.75	39
C.....	6	1.5	33

In conclusion, this species is quite distinct from, though related to, *Polynoë crinoidicola*, a species found on various unnamed crinoids in the Maldives by Professor Gardiner and described by me in 1910. The differences lie in the shape of the head and the tentacles and in the neuropodial setæ, but the general facies and the character of the elytra and the shape of the parapodia and of the dorsal setæ are similar. The specimens of *crinoidicola* are spoken of in one case as coming from a black crinoid and being themselves black when alive, though the pigment has dissolved out in alcohol. In other cases where the colour of the live animal and the host were not stated, the specimens were dark red. It seems certain, then, that the same type of colour resemblance occurs in the two species. In Torres Straits, too, I found the commensals always of a dark, almost black appearance and frequenting dark-coloured crinoids. They must, I think, be absent or rare on the lighter coloured hosts.

The only other reference of which I have knowledge to commensalism between a polychæte (?) and a crinoid is in Alcock's "A Naturalist in Indian Seas," p. 113, where he mentions a "sea-lily (*Actinometra*) striped in alternate bands of yellow and purple, on whose fronds similarly striped crustaceans live without fear of detection;" which in some places also gives "secure shelter to seaworms, banded yellow and purple like itself." This indicates a much wider range of pigmentation than in the present case. The banding is probably longitudinal, as in all other cases of commensalism.

THE COLOURATION OF THE MYZOSTOMIDS AND ITS RELATION TO THAT OF THEIR HOSTS.

From time to time remarks have been made on this subject. Semper* relates that he found his *M. tuberculosum*, which is spotted with red and yellow, only on variegated Comatulas, while the uniformly coloured *M. cirriferum* is found only on the red Comatulas, which it matches in colour. Von Graff,† however, remarks that though *M. glabrum* has a number of pronounced colour varieties, and the host *Comatula europæa* s. *mediterranea* varies within the same limits and almost with the identical shades of colour, yet his experience leads him to deny that any such definite mimicry relation exists between crinoid and myzostomid. A special investigation of over 200 comatulids showed that blackish, yellow and white myzostomids were just as frequently to be found on red Comatulids as blood-red myzostomids on variegated comatulids, and that the two kinds specially mentioned by Semper are uniformly distributed on the different colour varieties of the crinoid.

---

*Semper, Zur Anatomie und Entwickelungsgeschichte der Gattung Myzostoma. Zeits. f. wiss. Zool. Bd. IX, pp. 48–65, 1858.

†von Graff, Das Genus Myzostoma. p. 77, Leipsig, 1877.

Von Graff quotes, however, a passage from a letter written by von Willemoes Suhm,* showing that myzostomids may correspond perfectly with their host in colour pattern. The case mentioned is that of *Myzostoma horologium* v. Graff on crinoids which were probably *Comatula rotalaria* and *Comatula solaris*. The passage runs as follows:

"In der Arafura-See habe ich im vorigen Jahre einmal 80 Exemplare einer grossen Comatula untersucht und fand circa auf jeder zehnten unsere Schmarotzer. . . . Alle dieser Myzostomen waren, wie die Comatula, weiss und schwarz gefleckt, und die ubrigen zahlreichen Schmarotzer des Thieres zeigten dieselbe Färbung."

The myzostomids found on the crinoids of Murray Island were very numerous and belonged to several different species. Dr. C. L. Boulenger, of Birmingham University, has been kind enough to undertake their identification. They are in many cases very brightly coloured and have pronounced colour patterns. Generally speaking, there are two types of pattern. In the first concentric rings of bright and dark pigment alternate. In the second the dorsal surface is ornamented with radiating ridges, and these are usually free from pigment or very light coloured. The ridges are thrown into relief by an edging of a dark pigment (*e. g.*, purple or black); the general ground colour between the ridges as a rule approaches that of the crinoid on which the parasite was found. One of these forms was very common on the dark green or black varieties of *Comanthus annulatum*. The alternate black and non-pigmented rings are in vivid contrast, but the myzostomid is thin and the non-pigmented parts are so transparent as to be inconspicuous against the dark ground of the host. This species seems to occur only on the darker crinoids. In another species the same arrangement is found, but much lighter hues prevail, green pigment alternating with very light brown. The colours of the host were, unfortunately, not noted.

When the host is very light coloured the alternation of darker rings does not occur. On a green variety of *C. annulatum* a specimen of Myzostma was found which matched it perfectly. The greater part of the body was bright green, but a few white spots represented a broken ring of a lighter colour; the edge was relieved by dashes of black pigment, while the cirri were brownish. A very magnificent example of the second type of colouration was secured on October 24, 1913, on a green form of *C. annulatum*. It resembled its host closely and was comparatively inconspicuous. The general colour was a bright green; the ridges appeared greenish white, darker at the edges owing to the addition of a granular pigment, and round each there was an intense black line. An allied form was found on darker crinoids; there the ridges were white or yellow surrounded by a darker line (in one case

*von Willemoes Suhm, Zeits. f. wiss. Zool. Bd. xxvi, 1876.

purple) and the ground colour was brown. Lastly, in one or two forms almost the whole upper surface may be covered by a dark pigment. Thus, is one specimen, the dorsum was a dark green, only relieved by a white line down the middle, while in another, the dorsum was purple. These occurred on dark crinoids.

On the whole, then, the myzostomids showed a great colour resemblance to their hosts, though (as in the preceding cases) striking exceptions occurred and, even when the colour schemes harmonised, protection from human sight at least was not always secured.

GASTEROPODA.

Two or three very small gasteropods, apparently parasitic, were found on the crinoids. While one or two were colourless, one individual (which occurred upon a very handsome crinoid striped red-brown and yellow) was very similar in colouring to its host. The shell was perfectly transparent, but the body was red-brown, with distinct yellow spots. Mr. G. C. Robson, of the British Museum, has kindly undertaken the description of this individual.

SUMMARY.

The object of this paper is to point out that of the large number of species belonging to many phyla which habitually shelter amongst the branches of the crinoids of tropical reefs, by far the greater proportion exhibit colour resemblance to the host. As the colour scheme of the host is often extremely variable (*e. g.*, *Comanthus annulatum*), that of the commensal, in some cases at least, varies too, but some commensals seem to be restricted in their response to the stimulus which causes this colour resemblance. Thus among the Crustacea, in *Synalpheus* all stages of variation are met with, according to the individual inhabited, between a pale form with very narrow stripes of pigment, to an extreme form totally covered with dark pigment; while in *Cirolana*, on the other hand, the individuals associated with even the darkest crinoids possess only insignificant lines of pigment on the otherwise totally white body. In the latter case there is, then, no protective resemblance, although we witness the incipient stages of its establishment. Other forms like the polychæt, the amphipod, and the brittle-star, *Ophiomaza*, give rise to dark varieties only and occur upon dark-green crinoids.

The following represents in a tabular form the results of the observations:

Commensal.	Pigments developed.	Host and colour variety of host.
Synalpheus brucei	Purple-black	All colour varieties of Comanthus annulatum and some other crinoids.
Synalpheus brucei	Red	Comatula purpurea.
S. comatularum	Brownish purple, purple and white.	All colour varieties of Comanthus annulatum and some other crinoids.
Cirolana lineata	Red or purple in faint thin lines, rest white.	All colour varieties of Comanthus annulatum and some other crinoids.
Cyclotelson purpureum	All purple	Dark varieties of C. annulatum.
Pontoniopsis comanthi	Bright green and black or yellow and red-brown.	Light (green or yellow) varieties of C. annulatum.
Periclimenes spp	Red and blue-purple	Dark varieties of C. annulatum.
Ophiomaza cacaotica	Dark purple, brown or black.	Dark varieties of C. annulatum (one exception).
Ophiomaza cacaotica var. *picta*	Black and white	Dark varieties of C. annulatum.
Ophiomaza obscura	Dark brown and dull yellow.	Dark varieties of C. annulatum.
Polynoë minuta	Dark brown or black	Dark varieties of C. annulatum.

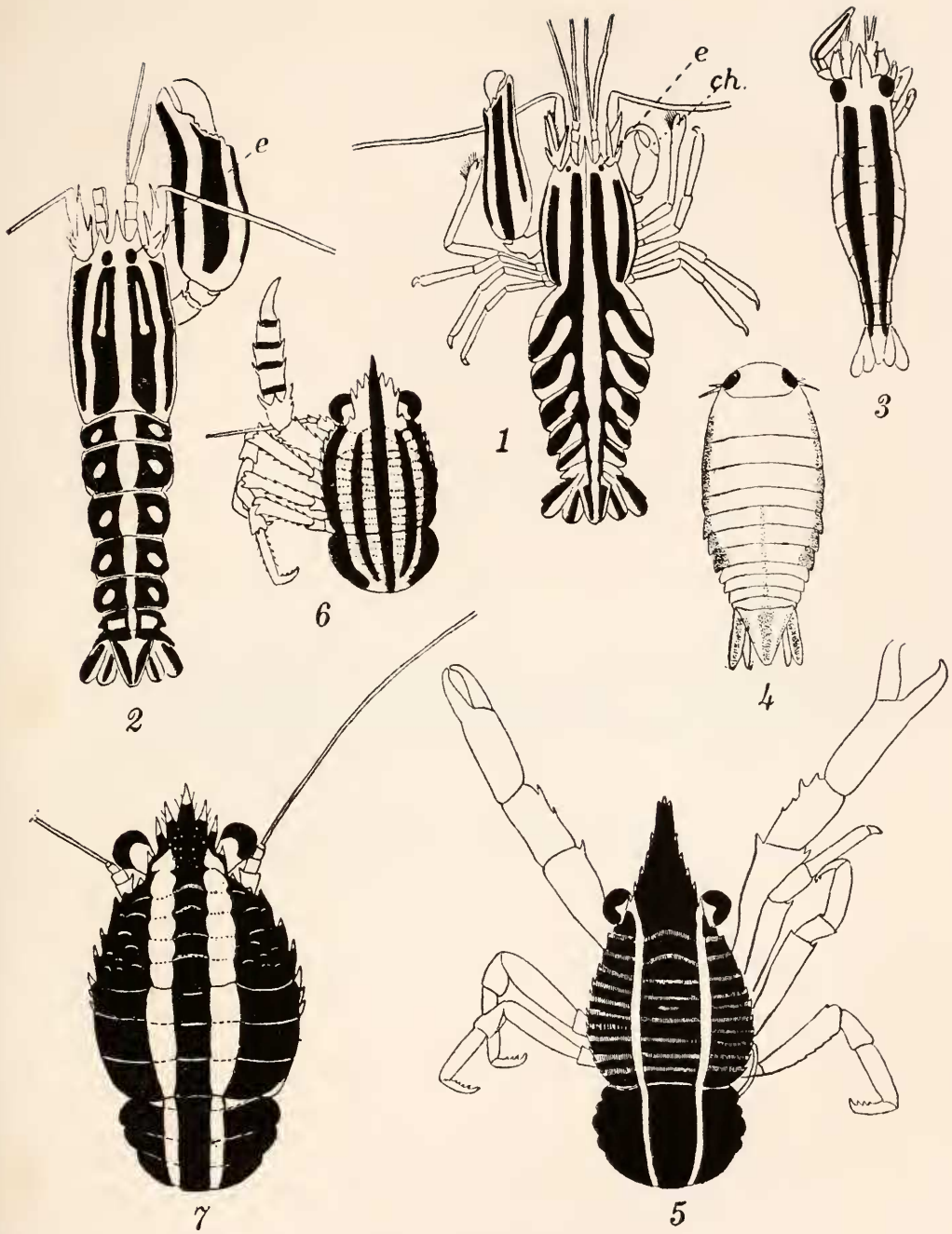

FIG. 1 *Synalpheus comatularum*. ×1.5.

FIG. 2. *S. brucei*: *e*, eye; *ch.*, small chela with its incurved thumb. ×3. Only a single example of *S. comatularum* and another of *S. brucei* is figured, so no idea of the variation in extent of pigmentation is shown, but only the type of arrangement. But both the type and variation are alike in the two species, that of *S. brucei* having rather deeper pigmentation, the bands being wider and the lateral unpigmented areas in the abdominal segments being completely enveloped by pigment.

FIG. 3. *Pontoniopsis comanthi*. ×6. FIG. 4. *Cirolana lineata*. ×7.

FIG. 5. *Galathea elegans*. ×4. FIG. 6. *G. minuta*. ×5. FIG. 7. *G. inflata*. ×6.